



# Proceedings of the Next Generation Exploration Conference

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### A Letter from the Editors

The Next Generation Exploration Conference (NGEC) brought together the emerging next generation of space leaders over three intensive days of collaboration and planning. The participants extended the ongoing work of national space agencies around the world to draft a common strategic framework for lunar exploration, by including other destinations in the solar system. NGEC is the first conference to bring together emerging leaders to comment on and contribute to these activities. The majority of the three-day conference looked beyond the moon and focused on the ‘next destinations’: Asteroids, Cis-Lunar Space, Earth 3.0, Mars Science and Exploration, Mars Settlement and Society, and Virtual Worlds and Virtual Exploration.

Three participants from each group were further given the opportunity to demonstrate their leadership skills through moderation and rapporteur responsibilities, resulting in a conference attended, organized, and executed by peers. In addition, participants were encouraged to contribute content real-time, via online collaboration tools. As one participant observed, the major difference between this conference and any other within the space sector was that over 90% of participants were on their laptops.

This conference demonstrated the power of tomorrow’s leaders and how the tools and technologies that NASA is beginning to employ can engage people in accomplishing its mission. By the time humanity gets to the Moon, Mars, asteroids and beyond, it will be in a networked, transparent, and socially responsible fashion. This is because the next generation of space leaders will have a different worldview and mode of operations – one that is quicker, more participatory, and more demanding than ever before. Engaging young people now, when space agencies are just beginning to plan for the next generation of space exploration, will leverage the next generation’s passion, drive, and new ways of executing projects and working together.

This proceedings book is a compilation of the intense activities during the three days of the conference. Many lessons were learned in this process, and we look forward to implementing them in the next ‘NGEC-like’ conference.

We would like to thank the NASA’s Exploration Systems Mission Directorate (ESMD) for contributing financially to making this conference possible, and in particular to Tom Cremins, Debbie Scrivner, and Jeff Volosin. The staff at NASA Ames Research Center was incredibly helpful in making NGEC a success, and we would like to thank Rho Christensen, Karen Bradford and Shirley Berthold for their leadership and unparalleled support. We would also like to thank Tek Okimura for his technical and computer support that made it possible for the participants to work with real-time, collaborative tools. There were non-United States participants during this workshop, and so we would like to thank ESMD for their support, the Ames international visitor Shirley Berthold, and Garvey McIntosh in the Office of External Relations at NASA Headquarters for enabling international participants on such a short notice.

#### **Attendees at NGEC**

166 people total

Average age 28

24% international

32% students

45% NASA civil servants and contractors

Countries (16)--Italy, Japan, Canada, France, China, Australia, Spain, Germany, Turkey, Norway, the Netherlands, Ireland, India, Switzerland, United Kingdom, South Africa

The thought-leaders behind the idea of NGEC were participants at the April 2006 ESMD Exploration Strategy Workshop and we would particularly like to thank Loretta Hidalgo Whitesides and friends within the Space Generation community.

We would like to thank all the speakers for taking the time to teach and guide the NGEC participants during the conference. The participants, moderators, and rapporteurs themselves contributed tirelessly during the three days, and we would explicitly like to thank Audrey Schaffer for her assistance in liaising with ESMD and editing all the chapters within these proceedings. We would also like to thank Benjamin Sanders for an excellent job co-moderating the Mars Settlement and Society, JoHanna Przybylowski for rapporteuring the Virtual Worlds and Virtual Exploration working group and for her leadership in writing and editing their contribution, and Alexandre Lasslop, Michael Collie, and Maraia Hoffman for leading the development of the NGEC Forward and NGEC Declaration.

We would like to thank Jennifer Bailey as the NGEC conference manager, for devoting over two-months to realizing this conference and Julie Fletcher for the design and layout of these proceedings.

Finally, we would like to thank the NASA Ames Research Center Director Pete Worden for his vision to enable tomorrow's generation of explorers to become leaders today.

Two handwritten signatures in black ink. The signature on the left is 'Robert Fuller' and the signature on the right is 'Kenneth Dyck'.

*"Man must rise above Earth  
to the top of the atmosphere  
and beyond,  
for only then will he  
fully understand the world  
in which he lives."  
Socrates (470-399 B.C.)*

Socrates uttered these words over two thousand years ago, and they still hold true today. In today's society, however, wonder at the night sky is not enough to sustain public interest in the space program. Much of the public feels that we have already discovered the 'new continent' of space and that the most important advancements are behind us. People today seem more concerned with the problems of today than the possibilities of tomorrow.

Given this situation, the global space community must show its relevance to today's society. Addressing this topic dominated much of the Next Generation Exploration Conference (NGEC), sponsored by NASA's Exploration Systems Mission Directorate (ESMD), August 16 to 18, 2006, at NASA Ames Research Center. Over 160 young and bright emerging space leaders from more than 15 countries collectively pooled their talents and skills to provide the global space community with honest feedback regarding its current strategies. The NGEC participants were divided into six groups, each looking at a future 'destination' for exploration. The detailed findings of each discussion group are laid out in the following pages.

From the heart of many discussions emerged a common theme: **How can the global space effort again become a source of imagination and hope for a brighter future?** How can the global space program reinvent itself to show its necessity in today's cultural, political and economic climates? Our answer: **The space program must become a solution.**

Following are several ways space programs can demonstrate how they are the answer to our greatest national and international challenges, and that by investing in space activities we increase the likelihood of a long and prosperous future.

**#1 - Create new economic markets based around space. Partner with private industry to pioneer new technologies, revenue streams and energy solutions in space.**

- An entirely new industry, based around space, is emerging. Ensure exploration's future by becoming the focal point and prime enabler of the inevitable move to private space development.
- Help create financial incentives for private industry to explore space. We believe the 21st century is likely to have similar incentive structures to the past. Where it is possible to make money, growth will follow. Could some government space activities be privatized to generate revenue? Could additional space research be funded if private industry could benefit economically from the results of such research?

- Investigate solutions to our power crisis using space technology. How can space agencies use space and private industry as a way to solve this problem?
- Explore the thousands of Near Earth Asteroids (NEAs) that are rich in metals, water, and organic materials. Can harvesting NEAs be profitable?
- Create an arm of each space agency dedicated to finding and driving applications of current space research. If agencies provide additional support to commercial firms, can we leverage the economic drive of private industry to maximize technological growth?
- Ensure the public is aware of exploration-derived technology by developing brand stickers, such as those found on most laptops ("Intel Inside," for example). Will public awareness improve perceptions about the space program?

## **#2 - Leverage society's proven allegiance to science to promote exploration.**

- Promote a dialogue on how science is enabled by exploration, to create public awareness of the value of exploration.
- Establish an international advisory body, consisting of young professionals, scientists, and space agency outsiders of multiple disciplines (including those in the arts) to provide regular updates and recommendations on how to communicate the value of exploration in enabling science. Encourage space agency officials to attend these meetings, as participating in a verbal dialogue will be far more effective than a reading a summary.
- Promote the idea that Earth is not separate from space. What we learn 'out there' profoundly affects our life on Earth. Space is the journey we all benefit from, not the destination of a few.

## **#3 - Lead the global community in solving educational crises to promote science and technology.**

- Education is the avenue by which we can inspire the world. The Apollo program was able to capitalize on the excitement of new frontiers to inspire the public in the 1960's. Today, we must use different tactics because space is not as exciting for many people. Education can be our new tool to inspire the public by inspiring our children.
- Space has always been a source of amazement to children. Sponsor programs that powerfully motivate and inspire youth. Create curriculum and benefit from programs that inspire children to pursue science and technology.
- Create a mentor program for students and young professionals. Provide incentives for individuals in the space industry to pass on their knowledge and skill sets to the next generation. Do not lose expertise at retirement.

- 'Virtual worlds' offer the opportunity to shatter barriers to collaboration and participation by providing worldwide access to comprehensive modeling tools, contextual databasing, and interactive collaboration forums. Virtual worlds have the power to tap currently underutilized resources and ideas, resulting in an inclusive community of explorers. From kindergarten students to career researchers, individuals across the world can contribute to a common goal.

We highly recommend that global space agencies redefine themselves in terms of the problems they can solve today, in addition to the dreams they can realize tomorrow.

Recognizing that endeavors such as space exploration require the cooperation of multiple generations, the collaboration of space-faring nations with those soon space bound, and the teamwork of governmental space agencies and private industry, we humbly offer the above recommendations.

With this in mind, we also want to promote a credo of respect, which should remain in sight while our species explores and expands into our surrounding universe:

**Human beings want to and should explore the solar system and beyond, and do so in an ethical way, in order to understand, protect, preserve and expand all lifeforms – including our own - and move from scientific-driven exploration to a new multi-planetary society.**

Everyone present at the 2006 Next Generation Exploration Conference strongly supports international collaboration in space exploration; we benefited from the opportunity to interact with our peers from other nations. We thank NASA's Exploration Systems Mission Directorate many times over for the opportunity to contribute to the most esteemed space endeavor in human history. We have been honored and inspired by the request for input.

May our involvement help to deliver the magnificent future we all imagine.

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# **Executive Summary** from the **Next Generation Exploration Conference**



Over 160 young space professionals from 16 countries met at NASA Ames Research Center from August 16 to 18, 2006, with the support of NASA's Exploration Systems Mission Directorate (ESMD), to discuss the long-term goals of space exploration. The participants, including scientists, engineers, educators, philosophers, entrepreneurs, and futurists, addressed six exploration 'destinations': asteroids, the cis-lunar (near-lunar) environment, Earth 3.0 (the likely state of future Earth), Mars science and exploration, Mars settlement and society, and virtual exploration. Based on discussions, the participants prepared the following statements and recommendations:

**Asteroids** – The economic potential of thousands of near-earth asteroids (NEAs) will help support future exploration endeavors and human presence in space. Strong evidence suggests that NEAs are rich in metals, water, and/or organic materials, and reaching them will require relatively low fuel costs. Extracted materials from NEAs can be used to manufacture structures, fuel, and other resources for mankind's exploration of the solar system. In addition, NEAs have a large range of orbits, essentially making them traveling resource platforms that also can be used for low-energy transportation for scientific study of our solar system. Finally, as history has proven, NEAs can collide with Earth and have catastrophic consequences to life and infrastructure. Exploring and understanding asteroids is essential to humanity's future, both on Earth and in space.

**Cis-Lunar** – Space agencies are committed to the "safe, sustained, affordable human and robotic exploration of the Moon, Mars, and beyond." This statement, while noble, does not explicitly define the ultimate goals and motivations of their activities. We recommend they communicate a more meaningful goal in order to portray a sense of purpose to the public. The goal discussed by the cis-lunar group is to create sustainable human settlements on the Moon and Mars, with the motivation to preserve the human race. All secondary exploration and science objectives flow from this main goal and are will be imperative to success. As an economic guiding principle, space agency activity should be limited to those areas where only government can perform the activity, and agencies should coordinate with the larger private and military sectors elsewhere. Also, space agencies must continue to fund the interdisciplinary science necessary to characterize environmental hazards associated with dust, radiation, surface charging, topology, and meteorites, to ensure our first attempts at extraterrestrial living are viable.

**Earth 3.0** – We affirm the principle that a viable human space exploration program must be conducted hand-in-hand with a comprehensive scientific research program that incorporates both the physical and life sciences and that continues to protect and extend understanding of our home planet. Without advances in life science, we will be incapable of devising self-sustaining extraterrestrial habitats, and we will struggle to survive on the only living planet we know. Without advances in the physical sciences, we limit our ability to imagine new technologies for space travel and to understand the nature of the universe we explore. Scientific advances expand the boundaries of humanity's dreams.

**Mars Science and Exploration** – Scientific discovery and technological development drives human advancement. Mars provides a unique and vital destination for such research. In addition, the exploration of Mars can provide significant social benefits back on Earth. International cooperation will not only be essential to the success of a human presence on Mars, but development of such international collaboration processes would jumpstart collaboration on other global issues. The eventual commercialization of space holds tremendous opportunities for economic growth. Furthermore, there is an undeniable basic human need to explore and define our place in the universe. The overarching theme that ties together all of these reasons for exploration is inspiring and uniting the global community. Continuously inspiring the public, the scientific community, and the community of Earth is required to achieve the goals of Mars science and exploration.

**Mars Settlement and Society** – Humans have an innate need to explore and expand their knowledge of the universe. We envision a future where humans not only visit Mars for short periods of time to conduct discrete scientific and business projects, but a future where humans live long-term productive lives beyond the confines of Earth. The Mars Settlement and Society group therefore focused on five key areas, with the understanding that the long-term implications of Mars exploration must be considered early in the process, in order to assure final success. The five key areas are Human Subsystems, Habitat Design, Community Infrastructure/Government, Creating Stakeholders, and Philosophical Framework. It was obvious for the study groups of all these areas (who shared the common drive to engage, inspire, and educate the public in order to create true stakeholders for the human exploration of the solar system) that a number of crucial topics such as legal and governing systems, group dynamics and psychology, issues of reproduction and human development, and the creation of a strong philosophical framework for Mars exploration still needed to be investigated. These objectives permit us to focus on both long-term goals and near-term tasks and will prepare us to arrive at and, more importantly, to stay on Mars. Therefore these objectives and themes should be important parts of an international dialogue on exploration strategies.

**Virtual Worlds and Virtual Exploration** – Virtual worlds will forever alter the landscape of exploration, revolutionizing every aspect of research, design, implementation and resolution, shattering the barriers to collaboration and participation. By providing worldwide access to comprehensive modeling tools, contextual databasing, and interactive collaboration forums, virtual worlds will tap currently underutilized resources and ideas, resulting in an inclusive community of explorers, ranging from kindergarten students to career researchers, contributing to a common goal.

Recognizing that endeavors such as space exploration require the cooperation of multiple generations, the collaboration of space-faring nations with those soon space bound, and the teamwork of government space agencies, private industry, and the general public, we have identified a number of issues which warrant considerable attention. For progress to be made, we must address the following issues in the following ways:

- Funding opportunities and procedures are currently not adequate for ensuring the successful completion of humanity's first step into the exploration of our solar system, the return to the Moon, nor for establishing a capacity for long-term missions on its surface. Funding opportunities for lunar science should recognize the many interdisciplinary studies that are possible, resist the "old-fashioned" approach to fund solely traditional areas of study, and be comparable in size to opportunities in the Mars program. Most important, space agencies should support science that characterizes the lunar environment.
- The public presently does not feel engaged in the space conversation. Space agencies should utilize non-standard means of public outreach, as well as additional tools at their disposal, to enable them to recover the public's attention and interest. Two-way communication that allows the public to participate in space exploration activities in a meaningful way will gain more public support for the goals of space exploration.
- Utilizing commercial resources is critical to achieving the primary goal of permanent, self-sufficient space settlements. Therefore space agencies need to be at the forefront of developing this space sector and encouraging political leaders to find an internationally accepted resolution to the legal uncertainty that surrounds space resource utilization. Space agencies' role in this new era should be to promote and enable private sector involvement from the outset, support private space business and the commercial development of

space technologies, and therefore identify a clear transition path away from exclusively government-run space exploration programs.

- The exploration and expansion of humanity into our nearby solar system, and eventually beyond, must occur with respect for the unique environments we encounter. The international community must review and adapt the planetary protection protocols currently in use, to prepare for this new endeavor.
- The mean age of space agencies employees – at least in the western world – has tended away from the young profile present at the early stages of space exploration. An international, interdisciplinary advisory body, composed of young professionals and scientists, should meet regularly to ensure close contact between the space agencies and commercial interests and young leaders who will implement exploration goals.
- Various stakeholders are not aware of potential enablers both to and from conducting space exploration. For example, exploring Near-Earth Asteroids can enable early, sustainable exploration of the inner solar system by providing a source of resources. Potentials such as this must be promoted to policy-makers, the public, engineers and scientists.
- Some criticize permanent presence on other celestial bodies as “giving up” on Earth. Space agencies need to promote the idea that protection and extended understanding of our home planet can be gained through comprehensive, scientific investigations from space, incorporating both the physical and life sciences.
- Space agencies should develop the ‘language’ of the future: a way of communicating the intent of space exploration, rather than just the vocabulary. Although this concept may appear abstract, the necessity is real as is the possibility of its creation.

As members of the generation that will have, in our lifetimes, both the responsibility and empowerment to establish a permanent presence of man on the Moon, as well as begin the initial stages of extending of civilization into our solar system, we encourage space agencies and other stakeholders to act on our suggestions early in this process. We all enthusiastically look upward to the heavens and forward to the future, as we work together, in an international effort, to progress toward the future of humanity.

# **Letter to ESMD from the Next Generation Exploration Conference**

Doug Cooke  
 Deputy Associate Administrator,  
 Exploration Systems Mission Directorate  
 National Aeronautics and Space Administration  
 300 E Street SW  
 Washington, DC, 20546



September 5, 2006

Almost 170 “next generation” space professionals and students gathered at the NASA ESMD-sponsored Next Generation Exploration Conference (NGEC), held at NASA Ames Research Center August 16-18, 2006. As participants of the NGEC, we commend NASA on supporting this event and soliciting our feedback on the interim Global Lunar Exploration Strategy.

As the “next generation,” we are currently in the early phases of our careers in the space sector. Over time, however, we will become the leaders and managers of space exploration activities. Therefore, we consider ourselves critical stakeholders in the current strategy development.

Based on the comments of six working groups, we offer the following overall recommendations for Global Exploration Strategy development, in addition to the detailed inputs we have already provided to the Lunar Exploration Themes and Objectives. Briefly, our recommendations are:

- Engage additional stakeholder groups in global strategy development. For some groups, special attention must be made to overcoming barriers they face in participation. Ensure that feedback about the strategy is provided to all stakeholders in a timely manner.
- Define a higher-level rationale for space exploration than what is currently outlined in the Lunar Exploration Themes. This rationale should explain why the global community should explore and settle space, using reasons relevant to humanity.
- Continue to engage the “next generation” in strategy development and mission planning. Individuals currently in the early phases of their careers will move into leadership roles as we execute the Global Exploration Strategy that we define today.

Each of these recommendations is outlined further in the attached appendix.

The NGEC participants thank NASA for providing our generation with the opportunity to engage in the development of a Global Exploration Strategy. We consider the NGEC a first step in involving future generations in planning the path to tomorrow. Because we are the taxpayers, voters, and decision-makers of the future, we hold the future of space exploration in our hands. Engaging our generation today will be critical for continuing the exploration journey tomorrow.

On behalf of the participants of the  
 Next Generation Exploration Conference,

Robbie Schingler  
 NGEC Organizer, NASA Ames Research Center

CC:  
 Inst Assets and Invest Ofc/Mr. Cremins  
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## Next Generation Exploration Conference

### Response to NASA Exploration Systems Mission Directorate:

*Recommendations regarding the development of a Global Exploration Strategy*

#### **Engage Additional Stakeholder Groups**

To ensure a sustainable exploration program, stakeholders from across the space arena must be engaged, beginning today with the development of the Global Lunar Exploration Strategy. We have identified important stakeholder groups that seem to have been underrepresented thus far in developing the strategy. Engaging these groups further will encapsulate a broader set of perspectives, creating a more thorough, refined, and robust strategy.

We recommend additional participation by the groups described below, possibly via a forum similar to the NGEC and April 2006 Exploration Strategy Workshop. Whatever the method, however, early involvement of these groups will result in a more developed strategy and create buy-in from all stakeholders, increasing the chance that the strategy will remain viable over the lifetime of lunar exploration.

**Private sector** – As national space agencies push cutting-edge exploration outward, the private sector should become increasingly involved beyond low earth orbit. To ensure that the outcomes of publicly funded activities can feed toward the future economic development of space, ideas from the private sector should be considered as early as possible.

**International space agencies and emerging space-faring nations** – We commend NASA on involving 13 other space agencies in strategy development thus far. We note, however, that restrictive trade regulations have to an extent hindered involvement by representatives from a broader cross-section of nations. We implore world leaders to resolve these issues to promote a more fertile exchange of ideas. In addition, we recommend increasing the involvement of emerging space-faring nations, perhaps in mentor-protégé relationships.

**Military** – Objectives such as security and state-of-the-art defense technology go hand in hand with such a lunar exploration initiative. Where realistic, we recommend inclusion of military leaders and strategists.

**Academia** – Academic researchers can provide a unique perspective on the long-term future. A neutral outlook, not based on politics or profits, can focus on basic science and exploration. Support for academia is needed to advance knowledge in these areas and train future generations.

**General Public** – The general public will need to support exploration for it to be sustainable in the long run. In particular, today's students will be key to implementing the strategy because they will sustain the space sector workforce. To ensure the support of current and future generations, the public must become actual stakeholders, not just receivers of one-way communications about space activities. We recommend a proactive and interactive approach to engaging the public, utilizing participatory forums such as citizen juries and consensus conferences.

In addition to including all of the above stakeholders in the strategy development process from its start, we stress the importance of maintaining ongoing development and assessment of the lunar exploration strategy. We recommend the implementation of a structured feedback loop to encourage accountability and follow-through. Not all suggestions need to be accepted; however it is important to make sure contributors know their inputs have been considered.



## Define a Rationale for Exploration

While we recognize the value of the core and crosscutting themes outlined in the Global Lunar Exploration Strategy, we found that questions pertaining to the purpose of space exploration were left unanswered. In this age and political climate, we feel there is no rationale offered to explain to the public and political leaders why public funds should be spent on space exploration.

In response to this uncertainty, we recommend that the exploration strategy more deeply examine the fundamental rationale for engaging in space exploration and express it at a higher level than what is currently addressed by the lunar exploration themes. The rationale should be meaningful to the general public and answer the questions: Why explore? Why extend human settlement to space? Why do these things as a global community? This rationale should not be specific to lunar activities, but to all exploration.

While we did not have time at the NGEC to develop this rationale fully, we would like to suggest that exploration satisfies needs more fundamental to humanity than those described in the current themes. It is not the carrying out of a vision directed by a governing entity, nor the capitalization of an economic opportunity, but human nature itself that will ultimately propel our species to extend its presence in the universe. Our exploratory nature, our need for survival, our search for life beyond our own, and our endless pursuit of peace on Earth make up a core motivational platform upon which the rationale for exploration objectives can be built.

**Exploratory Nature** – There is no shortage of historical examples to demonstrate the existence and importance of the human instinct to explore. This innate human presence has driven us toward global settlement, and the eventual extension of civilization to other worlds.

**Survival Instinct** – While the meaning of our existence in the universe is debated, the need to protect it is not. As long as humans remain confined to a single planet, there is a possibility that a catastrophic event could end civilization. Such events include a global disease pandemic, asteroid or comet impact, and nuclear war, among others. Extending human civilization to space could enable our species to avoid extinction after such a devastation.

**Search for Life** – Humanity has long asked the question, “Are we alone?” We seek an understanding of our own existence and our place in the universe. Space exploration offers the opportunity to shed light on these topics through the search for evidence of life elsewhere in the universe. If life exists beyond the Earth, not only will that discovery shake the foundations of our worldview, but finding life that originated from a second genesis would give us a separate biological system to compare to our own. With this important second data point, we could learn how life works on a more fundamental level and contribute to our understanding of how to protect and enhance our existence.

**World Peace** – A benefit of space exploration can be the unification of humanity under one banner. As we journey further from Earth, we will lose our national identities and become representatives of all humankind. As many fortunate astronauts have observed, the view of Earth from space is without borders. While enhancing global partnerships is currently a “crosscutting theme” in the Global Exploration Strategy, we recommend elevating it to the level of an overarching rationale. Engaging the world community in the peaceful pursuit of common objectives should be a primary motivator for and benefit of cooperative space exploration.

### Engage the Next Generation

The participants of the NGEN were pleased with the opportunity to comment on the Global Lunar Exploration Strategy. As members of the community tasked with performing the daily work of today's exploration, we welcomed the opportunity to look beyond and anticipate the future direction of exploration.

We do not believe, however, that involvement of the "next generation" should begin and end with the NGEN or even the development of the exploration strategy. While, as the "next generation," we are currently in the early stages of our careers, as time progresses we will become the leaders for missions to the Moon, Mars, and beyond. In order for the next generation to be most effective in executing the global strategy, we must be involved in its creation and development. Again, we commend NASA for soliciting our input at the NGEN, but stress that our participation must be maintained beyond this single event.

To engage the space professionals of our generation, we propose the establishment of a Next Generation Exploration Analysis and Engagement Group. This group should establish a standing relationship with NASA and other space agencies and institutions, to provide input to future exploration strategy and activities, while serving as a conduit for engagement with the next generation. A group comprised of those at the NGEN, along with "next generation" representatives from the stakeholder communities discussed above, would be both representative of the global space community and a unique voice within it.

